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A Free-field Pure-tone Hearing Screening Test

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A FREE-FIELD PURE-TONE HEARING SCREENING TEST

BY

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This thesis is approved as a creditable, independent investigation by a candidate for the degree, Master of Science, and acceptable as meeting the thesis requirements for this degree; but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Adviser

Head of the Major Department

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R. E. L.

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INTRODUCTION

South Dakota State College requires a hearing test as part of a physical examination for all entering freshmen. The purpose of the test is to discover students with a significant hearing loss. The test, administered by the college's speech department, has been part of the examination program since 1952.

The first hearing tests, given by the department in the fall of 1952, were monaural pure tone sweep tests. Only one audiometer was available, and students were tested over several months, coming for tests at a time that was convenient for them. Under this plan, many entering students failed to appear. Too, the task of administering the test was unduly time consuming.

In the fall of 1953, the hearing test became a required part of the freshman orientation program. Still, only a single audiometer was available. Though about one subject a minute was screened by this procedure, hearing testing was a bottleneck and not all entering freshmen were tested. This method was used through the fall of 1956.

The test was again modified in 1957. A word intelligibility test was administered from a tape recording which was played to all entering freshmen through loudspeakers. There was evidence that this test, though it could be efficiently administered, did not discover students with highly significant hearing losses.[1]

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[1] History from an interview with Gayland L. Draegert, Director of the Communications Clinic, South Dakota State College, April 18, 1960.

Problems with earlier tests spurred the search for a more efficient instrument. In the fall of 1959, a tape recorded test was designed which presented pure tones rather than speech as the stimuli. The test was to be presented through a loudspeaker.

Webster experimented with a screening test of this general type about 1950.[2] In preliminary tryouts of his pure tone group test, Webster concluded that such a test was feasible.[3] Working under far from ideal noise conditions--obtrusive noises coming from airplanes, trucks, and marching men at the San Diego and Great Lakes Naval Training Centers--Webster found that noise was a greater problem in his loudspeaker test than non-uniformity of the sound field. The greatest defect in the test, according to Webster, was that a single point in time measured a subject's threshold. The free-field pure-tone test was designed to eliminate problems Webster had discovered.

The purpose of the test was to screen students rapidly and to discover those with hearing losses of a magnitude assumed to be a handicap in everyday activities.

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[2]John C. Webster, "A Recorded Warble Tone Audiometer Test Suitable for Group Administration Over Loudspeakers," Journal of Speech and Hearing Disorders, XVIII (June, 1952), 213-223.

[3]Noise conditions led Webster to abandon the pure tone test for a warble tone test.

PROCEDURE

The test was designed as a tape-recorded test in which test instructions, a calibration tone, and pure tone pulses were recorded on a continuous tape. The test was recorded and played back on a full-track, Model NS-35B Magnecorder at 7½ inches per second.

Establishing Intensity Levels

Levels caused some recording problems. Usable dynamic range for this better-than-average tape recorder, was not the 50 db that is ideally needed for the test. To make optimum use of available dynamic range, a calibration tone, the 0 db reference level, was recorded at the lowest level that seemed to give an adequate signal to noise ratio. Narration, on the other hand, was recorded at the highest possible level. There was a 35 db range between the calibration tone and the narration.

Taping the Test

Pure tones were recorded at four frequencies and at three sound pressure levels. The test frequencies chosen were those most important to speech: 500, 1000, 2000, and 4000 cycles per second.[4] One-thousand cycles was used as the calibration frequency and was recorded at the 0 db reference level. All four frequencies were recorded at three levels above 0 db reference level; 10, 15, and 20 db. The 500 cycle tone was

[4] Hayes A. Newby, Audiology (New York: Appleton-Century-Crofts, Inc., 1958), p. 14.

recorded 5 db higher than the other three tones.

Tones were put directly into the recorder from a Hewlitt-Packard Model 200 CD wide-range oscillator. Levels were metered on a Hewlitt-Packard Model 400D vacuum-tube voltmeter. The test was recorded on virgin Concordia "high fidelity" plastic base tape.

The test is a pulse-tone test. From zero to three stimuli are presented to subjects in each item. Subjects are to indicate on their answer sheet the number of tones they hear. All stimuli in a test item are at the same frequency, but where more than one tone is played, they are at diminishing levels.

Recording one-second tones with one second of silence between stimuli, then another brief tone at a lower level, posed a recording problem. The problem was solved by recording several seconds of tones at each frequency and at each level on a continuous tape, then building the test by splicing together one-second tones with one second of silence spliced between tones. Where fewer than three stimuli were presented in a test item, silence of the proper length was put in place of the missing tones so the number of stimuli could not be inferred from the length of the item.

Narration was spliced at the beginning and end of each item. A single test item is recorded in the following manner. The narrator announces the number of the item, corresponding to the item number on the answer sheet. This is followed by the test stimuli. The end of a test item is indicated by the narrator saying "Mark." Item 1, for example, is recorded as follows.

Narrator: "Number 1."
Silence : 1 second.
Tone : 1000 cycles at 20db, 1 second.
Silence : 1 second.
Tone : 1000 cycles at 15db, 1 second.
Silence : 1 second.
Tone : 1000 cycles at 10db, 1 second.
Silence : 1 second.
Narrator: "Mark."
Silence : 1 second.
Narrator: "Number 2."
Etc.

Items containing fewer than three stimuli are taped like Item 4.

Narrator: "Number 4."
Silence : 1 second.
Tone : 500 cycles at 15db, 1 second.
Silence : 5 seconds.
Narrator: "Mark."
Silence : 1 second.
Narrator: "Number 5."
Etc.

Twelve test items were recorded in this manner. Items contained from zero to three stimuli. Every tone is repeated twice at each level in different parts of the test. A 20 second rest break occurs between the sixth and seventh item.

The tape is recorded in four major divisions: (1) instructions for calibration, (2) the calibration tone, (3) instructions for the test tones, and (4) the twelve test items. The complete taping plan is in Appendix A.

Calibration

By definition, the normal hearing threshold is 0 db, a sound pressure level of 0.0002 dynes per square centimeter. This is the lowest sensation level at which a subject can detect a stimulus at least 50 per cent of the time.[5] A 0 db stimulus was recorded on the test tape, but calibration was still a problem. How do you know when you are playing the 0 db tone at the threshold level? Too, how can you get a dynamic range of 50 db or better out of a recorder with a 20 to 35 db range? These two problems are related and solving one solved the other.

Thirty-five db, the narration level, is not a comfortable listening level. To play narration at a comfortable level, a T-type attenuator pad was put between the tape recorder's output transformer and an external speaker. A single-pole-single-throw switch was wired in parallel with the pad (see Figure 1). With the switch opened, the T pad is in the circuit and attenuates the test signal. With the switch closed, the pad is shorted out of the circuit. The opened position is labeled "Test" and the closed position is labeled "Narration."

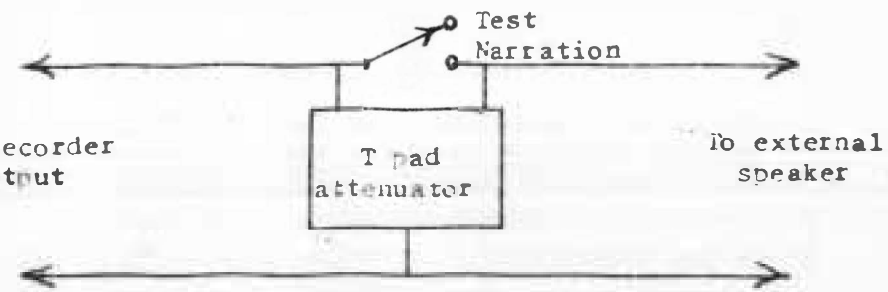

Figure 1. Calibration Attenuator

The test is calibrated as follows. Before subjects arrive, the recorder volume control is set at a comfortable level with the attenuator switch in the "Narration" position. When subjects are seated, the following instructions, which explain calibration, are played.

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[5] Newby, *op. cit.*, p. 93.

A tone that sounds like this (Tone: 1000 cycles at 35 db) will follow this explanation. At the end of the explanation, you'll be asked to close your eyes and raise your hands. This tone will be played loudly enough to be heard by nearly all of you, then the volume will be reduced until you can no longer hear it. When you can no longer hear the tone, quietly lower your hand.

Be as quiet as possible. Such things as shuffling feet, shifting posture, clearing throats, and releasing air from the lungs may tend to hide the tones.

Close your eyes and raise your hands now. Quietly lower your hand when you can no longer hear the tone. Open your eyes after you've lowered your hand.

The 1000 cycle, 0 db tone follows this narration. At the end of the narration, the attenuator switch is set in the "Test" position and the reference tone is slowly faded at the attenuator until an estimated 50 per cent of the subjects have lowered their hands. At this point the test is assumed to be calibrated at 0 db, the zero sensation level. Neither the volume control nor the attenuator pad setting is moved until the test is completed. Instructions, however, are returned to a comfortable listening level by putting the attenuator switch in the "Narration" position.

At the end of calibration, the tape is run to the beginning of the test instructions, the switch is put in the "Narration" position, and test instructions are played for the subjects. The attenuator switch is in the "Test" position for the sample item and the 12 test items. Narration announcing the beginning and end of items is low, but can be heard.

Complete instructions for administering the test are in Appendix B.

PURE-TONE FREE-FIELD HEARING SURVEY
SOUTH DAKOTA STATE COLLEGE

PLEASE PRINT

Name______________________________Date__________
Last First
College Address______________________________

Phone____________Session________Seat______________

	0	1	2	3
SAMPLE	☐	☐	☐	☐
1	☐	☐	☐	☐
2	☐	☐	☐	☐
3	☐	☐	☐	☐
4	☐	☐	☐	☐
5	☐	☐	☐	☐
6	☐	☐	☐	☐
30 second pause				
7	☐	☐	☐	☐
8	☐	☐	☐	☐
9	☐	☐	☐	☐
10	☐	☐	☐	☐
11	☐	☐	☐	☐
12	☐	☐	☐	☐

IMPORTANT INSTRUCTIONS:
Remain quiet
Face front

DO NOT WRITE IN THIS SPACE X

S ( ) L ( )
Contacted

Phone______________

Letter______________

Appointment

Date________Hour________

Do you now have or have you ever had problems with your hearing? yes ( ) no ( )
Explain______________________________
X______________________________

Figure 2. The Answer Sheet

The Answer Sheet

Subjects record their responses to test items on the answer sheet reproduced in Figure 2. The top and bottom of the form are filled in before the test is started. Subjects mark the answer sheet by putting an X in the box indicating the number of stimuli they hear. The answer sheet should have a vertical line drawn between the zero and one to help subjects, if they count stimuli as they hear them, start counting at one rather than zero.

The right side of the form is used to indicate passes and failures. s is the last letter of the word pass; l is the last letter of the word fail. Follow-up action is also recorded here.

The answer sheet may be scored with a punched key or the scorer can rather quickly memorize the correct answers. In scoring, changed answers, as well as those marked wrong, were considered in calling subjects for follow-up testing.

The Test Tryout

The test was administered September 16 and 17, 1959, to 783 incoming freshmen at South Dakota State College. Though copies of the test were made, the test was administered from the original tape. The proportion of men to women in the freshman class was 3.0 men for every woman. The estimated median age of the subjects is 19.

The test was given ten times. Test Sessions 1 to 3 were on September 16, Sessions 4 to 10 were on September 17. As can be seen in Table I, the number of subjects in sessions varied widely.

TABLE I. SCHEDULE OF TEST SESSIONS

Session No.	N
1	111
2	125
3	51
4	110
5	110
6	101
7	68
8	12
9	9
10	6
Total	703

The Test Room

The test was given in the college's Agriculture Hall A, a room with a seating capacity of 146. Subjects were not allowed to sit in the first three rows, which reduced usable seating capacity to 111.[6]

The test room is acoustically good. There are no parallel walls. The front, one side, and a small section of the back of the room are brick. Most of the back wall is acoustical paneling. The remaining side of the room is plaster. The ceiling is of serrated design and finished with acoustical plaster. The floor is cement. The floor and ceiling are not parallel. Seats are wooden and not upholstered. They are fixed in position and have a writing arm that can be raised or lowered. The seats are new and rigidly constructed. They were not an obvious source of noise.

The test room is about 48 feet long. It is 36 feet wide at the

[6] Too many people were allowed into the test room for Session 2.

back and 18 feet wide at the front. The volume of the room is estimated at about 17,000 cubic feet.

A ventilation blower and another lecture room are off the left side of the test room. This lecture room was not in use during the test sessions. The test room's main entrance is to the back and the left. The right side of the room is an outside wall. A highway runs past the front wall of the test room, 30 feet from the outside of the building. A stairway is outside the back of the test room, though most of the back wall is an outside wall.

The test room is fairly reverberant, at least when empty.

Test Routine

Subjects arriving for the test were given an answer sheet and, where groups were large, allowed to choose their own seats. When groups were small, subjects sat in a compact group. When all 111 seats were filled, other subjects sometimes waited outside for the next test session. Two monitors tried, sometimes not with complete success, to keep the hall quiet while the test was given. At the end of the test, subjects turned in their answer sheets at the door as they left.

Three people administered the test. Two monitors passed out answer sheets and saw that subjects were seated, filling in empty seats and, except for Session 2, staying out of the first three rows. A third monitor operated the test apparatus and sometimes helped the other. At the end of the test, the two monitors collected answer sheets and stamped cards indicating that students had completed the hearing test.

The test was scored according to the number of incorrect items.

A punched key was first used for scoring, but was abandoned when the scorer found it easy to memorize the key. Tests were scored by individual sessions to discover instances in which test items were masked by noise or other problems occurred.

Validating the Test

Of the 703 subjects who took the group test, 125 were also given individual pure tone audiometer tests. These subjects were called in three groups.

The first sample was composed of subjects who missed items on the group test or indicated a history of hearing problems. This sample numbered 50. They were given audiometer tests between September 28 and October 27, 1959.

A second sample was chosen by numbering the test blanks from 1 to 703 and choosing 100 subjects from a table of random numbers. Of the 100 numbers chosen, only 50 were called. Of these 50, only 28 appeared for the test. Five more of these 50, however, were included in the third sample. Thirty-three of the 50 subjects eventually took the individual test. The 28 subjects were given audiometer tests between November 12 and December 4, 1959.

Because of student reluctance to appear for tests and the time involved in getting them in, a third sample included all students who had taken the group test and were enrolled in one of five different sections of the basic speech course or one section of freshman English. Forty-seven subjects are in this sample. Of those called, only one subject was not given the audiometer test. According to his instructor he dropped college. Audiometer tests were given to this third sample from February 9 to March 16, 1960.

The audiometer used for the individual tests, a Maico Model H-1, had not been calibrated since the summer of 1958. The calibration was checked as suggested by Newby.[7] A sample of 25 subjects was drawn from those who had passed the group test and indicated no history of hearing problems. Threshold level was recorded for each of these subjects and an average was taken. Results indicate that the audiometer was less than 4 db out of calibration at the four group-test frequencies. Four db is within specifications.[8] Results of the calibration check are recorded in Appendix C. This model Maico audiometer had been accepted by the American Medical Association on June 1, 1951.[9]

If subjects showed no loss at the four group test frequencies, audiometer tests were given at only these frequencies. If a loss was indicated at the group test frequencies, subjects were given a complete audiometer test.

Audiometer tests were given under far from ideal conditions. A hissing radiator caused problems. Too, pounding steam pipes outside the test room often interfered. The audiometer test room was next to a

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[7] Newby, op. cit., pp. 86-88.

[8] "Minimum Requirements for Acceptable Pure Tone Audiometers for Diagnostic Purposes," Journal, American Medical Association, CXLVI (May, 1951). Reprinted in Ira J. Hirsh, The Measurement of Hearing (New York: McGraw-Hill Book Co., Inc., 1952), p. 306.

[9] Hirsh, op. cit., p. 310.

lavatory. Another lavatory was on the floor above the test room. Water closets and chattering water pipes were occasional sources of noise. Intermittent loud noises, however, were less disrupting than the steam pipe in the test room. Subjects, as would be expected, complained most often of noise when being tested at 500 cycles.

RESULTS

The 703 tests were scored according to the number of items missed. Results are summarized in Table II. The IT in columns 4 and 5 refers to the individual audiometer test.

TABLE II. SUMMARY OF TEST RESULTS

Items missed	n	Per cent of N	Number given IT	Number failed IT
1	70	10.0%	11	3
2	39	5.6	32	21
3	8	1.1	4	2
4	5	.7	4	2
5	4	.6	3	2
7	1	.0	0	0
10	1	.0	1	1
Total	128	18.2%*	55	31
2 or more at same f	43	6.1%	31	27

*Column 3 does not add up to this percentage.

Determining Pass-Fail Criteria

The first problem was to establish pass-fail criterion for each of the tests.

The Individual Test

The Committee on Conservation of Hearing of the American Academy of Otolaryngology defines a medically significant hearing loss as (1) a loss of 20 db or more at any two frequencies in either ear or (2) a loss of 30 db or more at any single frequency in either ear.[10] A 20 db loss at any of the four group test frequencies seemed likely to indicate a medically significant loss when combined with frequencies not tested by the group test; therefore, for purposes of correlation with the group test, subjects with an individual audiometer test threshold of 20 db or more at any group test frequency failed the individual test.

<u>The Group Test</u>

Three possible fail criteria were considered for the group test. (1) Fail subjects who missed one or more items on the group test. (2) Fail subjects who missed two or more items on the group test. (3) Fail subjects who missed two or more items at the same frequency on the group test. To determine the optimum fail criterion for the group test, a sample population was chosen which included (1) all of those who failed the individual test at any of the four group test frequencies, and/or (2) all of those given both tests who missed one or more items on the group test. Results are summarized in Table III.

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[10] Newby, *op. cit.*, p. 710.

TABLE III. CORRELATION TABLE FOR THREE FAIL CRITERIA FOR THE GROUP TEST

		GT					
		One or more missed		Two or more missed		Two or more missed at same f	
		Fail	Pass	Fail	Pass	Fail	Pass
IT*	Pass	26	0	18	8	5	21
	Fail	30	1	28	3	28	3

*Individual test

Phi coefficient correlations for the different criteria are indicated in Table IV. Significance indicates the probability of the distribution in Table III occurring by chance.[11]

TABLE IV. OPTIMUM FAIL CRITERION FOR THE GROUP TEST

Criterion	Correlation	Significance
One or more missed	-.12	Highly insignificant
Two or more missed	.27	Significant at the .05 level Not significant at .01
Two or more missed at the same f	.72	Significant beyond the .01 level

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[11] Henry E. Garrett, Statistics in Education and Psychology (New York: Longmans, Green and Co., 1958), pp. 388-392.

From these correlations, the best fail criterion for the group test is two or more items missed at the same frequency. Using this criterion, five out of 57 subjects would have been given the audiometer test unnecessarily and three would have slipped through the screen.

Validity

After the pass-fail criteria for both the individual and group test, was determined, it became possible to determine the validity of the group test. The group test is validated against the individual audiometer test that was administered to the three sample populations.

Results, using the previously described pass-fail criteria, are summarized in Table V.

TABLE V. CORRELATION TABLE FOR GROUP AND INDIVIDUAL TESTS

		GT					
		Random sample		Error sample		Total sample	
		Fail	Pass	Fail	Pass	Fail	Pass
IT	Pass	0	70	6	19	6	89
	Fail	2	3	25	0	27	3
		N=75		N=50		N=125	

All distributions in Table V are significant beyond the .01 level. Phi coefficient correlations are summarized in Table VI.

TABLE VI. CORRELATION BETWEEN THE GROUP TEST AND THE INDIVIDUAL TEST[12]

Sample	Correlation
Random sample	.62
Error sample	.78
Error sample, neglecting those who failed the GT and passed the IT.	1.00
Total sample	.84
Total sample, neglecting those who failed the GT and passed the IT.	.93

From these correlations, it appears that we can assume that those who fail the group test are likely to have a significant hearing loss. But we are on less firm ground in assuming that those who pass the group test do not have a significant loss, though our inferences are probably better than the random sample correlation indicates. If the audiometer test fail criterion were reduced 5 db, to 25 db, the correlation for the random sample would be 1.00.

Of the subjects who were not properly screened, the greatest concern is for those with losses who passed the group test. Three subjects who passed the group test did fail the audiometer test. Another subject

[12] Phi coefficient is used instead of tetrachoric r because, with the distributions in Table V, rt gives an exaggerated correlation. rt for the random sample would be 1.00. Garrett, op. cit., pp. 384-388, 450.

with a 25 db loss at 4000 cycles passed the group test at that frequency, but failed it at 1000 and 2000 cycles.

The first subject (224) who got through the screen had a loss of 20 db in the left ear and 30 db in the right ear at 4000 cycles. He was sitting half way back in the test room and to the far left. He did miss one of the 4000 cycle items. This loss, by definition, is medically significant, but not highly significant.

The second subject (443) who slipped through the screen showed a 20 db loss at 500 cycles in both the right and left ears. He was sitting about a third of the way back and in the middle of the right hand side of the test room. He missed no items on the group test. A note on his audiogram indicates that he was "inattentive" and "easily distracted" during the audiometer test. Noisy test conditions may have affected audiometer test results at this frequency.

The last of the three subjects (676) who got through the screen had a threshold of 20 db in the right ear and 35 db in the left ear at 4000 cycles. Too, he had a threshold of 15 db at 2000 cycles in the left ear. This subject did miss two items on the group test, but he did not miss either of the 4000 cycle items. The items he missed were at 500 and 2000 cycles. This subject was sitting in the second row and about a third of the way to the center from the left side of the test room. The loss of 35 db in the left ear at 4000 cycles makes this loss medically significant.

All three of these subjects were in different test sessions.

Per cent loss was calculated by the American Medical Association method.[13] Results are summarized in Table VII.

TABLE VII. PER CENT LOSS OF SUBJECTS WHO PASSED THE GROUP TEST AND FAILED THE INDIVIDUAL TEST

Subject	Better ear loss	Poorer ear loss	Binaural loss
224	1.7%	2.7%	1.8%
443	2.1	3.0	2.2
676	0.9	11.1	2.2

Though these losses are relatively insignificant, they are still disturbing. This situation might be remedied by more careful calibration of the group test.

It might be profitable to determine if the incidence of hearing loss discovered by the group test is what might be expected. Thirty-three subjects failed the group test and were given an individual test. Of these 33, 29 had a medically significant loss. Assuming the same proportion to hold true for the 10 subjects who failed the group test but did not take an individual test, the expected number of significant losses discovered by the group test would be 37.8. For 703 subjects this is an estimated incidence of 5.4 per cent of binaural loss.

Of the 75 random subjects who took both tests, 10 were discovered that had a medically significant monaural loss that was not discovered by the group test. This loss, if the rest of the population has losses in the same proportion, would indicate a 13.3 per cent incidence of monaural

[13]Newby, op. cit., pp. 102-104.

loss that was not discovered by the group test. Adding these two figures gives a predicted incidence of 18.7 per cent, which seems unreasonably high. The incidence discovered by just the group test is more in line with what might be expected.

Several factors tend to make incidence at South Dakota State College higher than average, however. (1) There were about 3.0 times as many men as women in the test population. (2) South Dakota has a generally inadequate hearing conservation program. (3) A high proportion of the test population was from rural areas. Median incidence, from a report by the Purdue Public School Hearing Test Service for the years 1941 to 1954, was 4.5 per cent for rural children compared to 3.9 per cent for city children. The Purdue report is based on 166,090 county children and 71,140 city children.[14]

There seem to be no data available on hearing loss incidence among college freshmen. There are, however, many statistics on the general school population. Steer has summarized many of these statistics.[15] According to Steer, the Federal Security Agency reported an incidence of 6.9 per cent for the 1938-1939 year. By 1944-1945, the incidence had dropped to 4.4 per cent as reported by the same agency.[16] Gardner, analyzing the data from all reporting agencies for 1947-1948, reported

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[14] M.D. Steer, "The Need for Hearing Conservation Programs in Schools" (Speech and Hearing Clinic, Purdue University), p. 12. (Mimeographed.)

[15] Ibid., pp. 2-8.

[16] Ibid., pp. 2, 3. From "Children with Impaired Hearing," Federal Security Agency, Childrens Bureau Publication No. 326, 1952, p. 22.

a national average incidence among school children of 4 per cent. His figure is based on more than 3,000,000 children, representing one-eighth of the country's school population.[17]

Reported incidence varies widely. Gardner reports incidence varying from 2.2 per cent to 17 per cent for reports covering 3,490,314 Oregon school children.[18] The Purdue summary for a thirteen year period indicates incidence varying from 2.5 per cent to 7.1 per cent with a median incidence of 4.7 per cent.[19]

Though incidence at South Dakota State College cannot be directly compared with these figures, it does appear that group test results did not indicate an incidence below what would be expected of a binaural test.

On the basis of the above data, it appears that, though there are some problems, the group test is reasonably valid as a binaural screening test. The test missed no one in the sample population with a significant hearing handicap. More careful calibration might improve the test's validity.

Difference by Seating Area

To determine whether or not seating position affected the results

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[17] Steer, op. cit., p. 3. From Warren H. Gardner, "Report of the Committee on Hard of Hearing Children," American Hearing Society, Hearing News, XVIII (1950), 5-8.

[18] Ibid., loc. cit. From Leland A. Watson and Thomas Tolan, Hearing Tests and Hearing Instruments (Baltimore: Williams and Wilkins, 1949), p.236.

[19] Ibid., p. 12.

of the group test, the room was divided into 10 areas and the results were arranged in a contingency table.[20] The room was divided as illustrated in Figure 3.

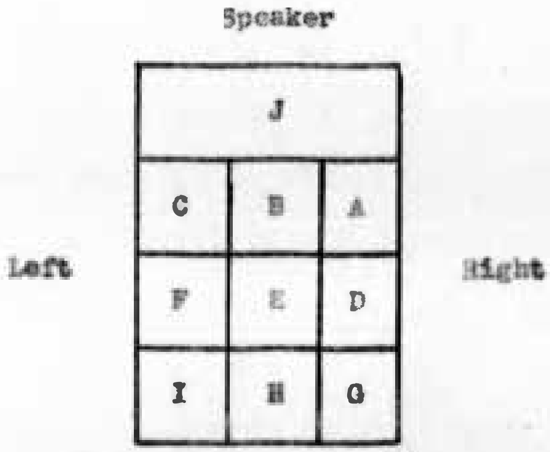

Figure 3. Seating Areas

Passes and failures by seating area are summarized for all three sample populations in Table VIII. Nineteen subjects out of the 125 did not indicate their seat number, therefore N is only 106.

TABLE VIII. GROUP TEST PASSES AND FAILURES BY SEATING AREA

		Seating Area									
		A	B	C	D	E	F	G	H	I	J
Pass	Observed freq.	8	6	15	9	6	12	2	6	7	7
	Expected freq.	8.1	4.4	11.8	8.8	6.6	11.0	4.4	7.4	9.6	5.9
Fail	Observed freq.	3	0	1	3	3	3	4	4	6	1
	Expected freq.	2.9	1.6	4.2	3.2	2.4	4.0	1.6	2.6	3.4	2.1

[20] Garrett, op. cit., pp. 262-264.

X^2 for this distribution is 15.467, which, with 9 df, has a probability between .05 and .10. Seating position does make a significant, but not highly significant, difference. Ideally, it should be highly insignificant.

Areas are listed in their order of significance in Table IX. Those listed first differed most from what would be expected if seating position made no difference; those listed last are closest to what would be expected if seating position made no difference.

TABLE IX. RANK BY SEATING AREA FOR SIGNIFICANCE

Seating area	X^2
G	4.910
C	3.306
I	2.691
B	2.182
H	1.018
F	.341
E	.205
D	.018
A	.015

<u>Front</u> <u>to</u> <u>Back</u> <u>Differences</u>

Unlike Webster's study[21] distance from the speaker seemed to be the most significant factor. The closest subject sat about 15 feet from the speaker, the furthest about 35 feet 6 inches. The middle seat in the test room, of those occupied for the test, was about 24 feet 6 inches from the speaker. Distance from the speaker to key seats is shown graphically in

[21] Webster, <u>op</u>. <u>cit</u>., p. 215.

Figure 4.

X^2 for areas ABC, the front rows, is 5.503 which has a probability between .05 and .10. Table VIII indicates that fewer people failed the group test in the front rows than would be expected.

X^2 for areas DEF, the middle rows, is .564 with a probability between .70 and .80. Nearly the expected number passed and failed in the middle section of the room.

Areas GHI, the back rows, differed highly from what would be expected if seating made no difference. The probability that this distribution occurred by chance is between .01 and .02. X^2 is 8.619. Table VIII indicates that more subjects failed in the back rows than would be expected.

The most significant difference was, as would be expected, from the front rows to the back rows. X^2 is equal to 14.122 which has a probability of between .01 and .02 with 5 df. The difference between the front and middle rows was least significant, X^2 equalling 6.067 for a probability of .30. The difference between the back and middle rows was significant, but less significant than the difference between the front and back rows. X^2 for the middle and back rows is 9.183 with a probability of .10 for 5 df.

Actual loss patterns for different parts of the room seem inconclusive. A 20 db loss was found in area J, the very front section of the room. The slightest loss discovered in the front rows, areas ABC, was 30 db with two 35 db losses and a 50 db loss. Two subjects in areas ABC with 15 db losses and two more with 20 db losses passed the group test.

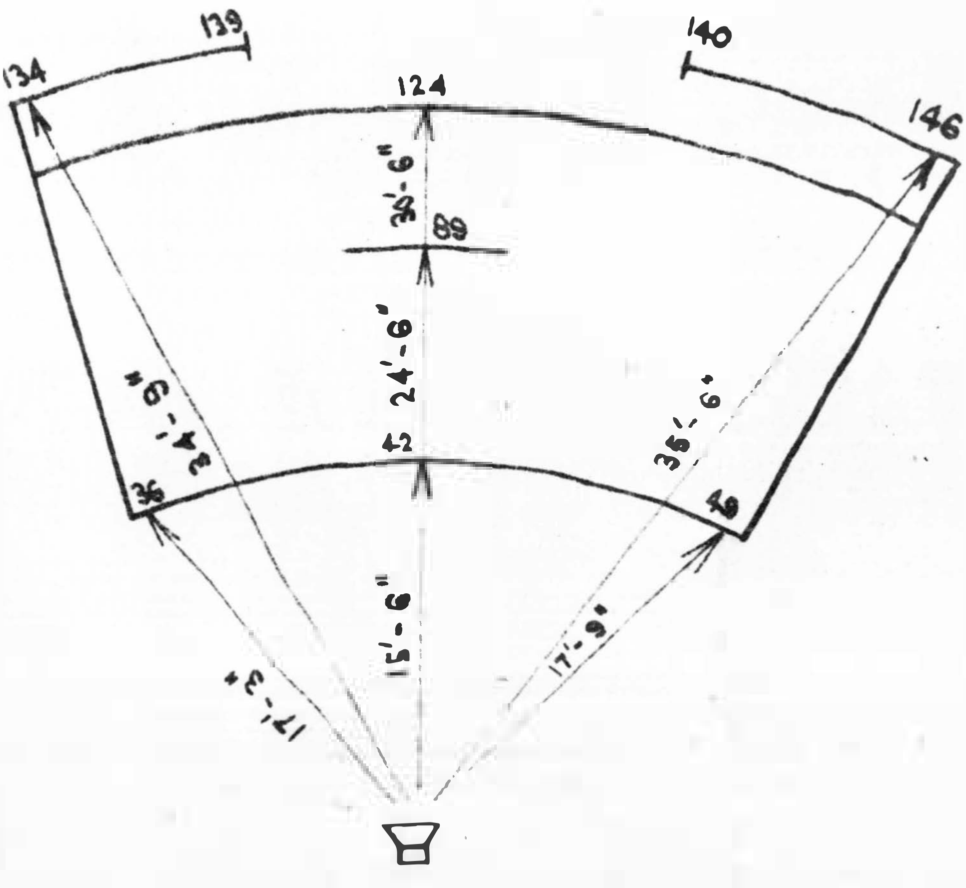

Figure 4. Distance of Key Seats from the Speaker

In the middle section of the test room, a 20 db and a 25 db loss were not picked up, although a single 10 db loss was. Two 25 db losses were discovered, however.

In the back of the test room, areas GHI, a single 15 db loss and a single 20 db loss were picked up. Four 25 db losses were found in the back of the test room.

It appears that a loss had to be about 25 db before it was fairly consistently picked up. Unfortunately, nobody with a 25 db loss either passed or failed the group test while sitting in the front rows.

Webster's conclusion that an unequal sound field was less of a problem than expected[22] and actual loss patterns seem to indicate that attenuated sound may cause only a part of the difference from the front to the back of the room. Subjects knew they were to have their hearing tested, but they did not know how the test was to be administered. They were allowed to choose their own seats. Perhaps part of the difference is that students who knew they had losses tried to avoid the test and, ironically, sat in the back of the room. This possibility should probably be further explored by seating subjects in random order.

Side to Side Differences

Whether subjects sat on the right or left sides or in the center of the test room did not make a significant difference. X^2 for right, center, and left thirds of the test room was 1.267 with a probability of

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[22]Webster, *op. cit.*, p. 215.

between .50 and .70 for 2 df. Data from Table VIII were regrouped and are summarized in Table X to show passes and failures by room side.

TABLE X. GROUP TEST PASSES AND FAILURES BY RIGHT, CENTER, AND LEFT OF TEST ROOM

		Right	Center	Left
Pass	Observed frequency	19	18	34
	Expected frequency	21.3	18.4	32.4
Fail	Observed frequency	10	7	10
	Expected frequency	7.7	6.6	11.6
	Total	29	25	44
	X^2	.934	.033	.300

The right side of the room, the side which differed most significantly from chance, was furthest from the entrance and blower room which were sources of noise. Still, more subjects than would be expected failed on the right side of the room. Results are the opposite of what would be expected. The sound field emitted by the speaker or placement of the speaker may be partly responsible for the difference between the right side of the room and the left and center areas.

Significance of Differences by Session

Not only might there be a difference by seating position, but there might be significant differences from test session to test session as well.

The test was administered 10 times. The number of subjects in the sessions ranged from 125 in Session 2 to 6 in Session 10. Sessions are ranked in their order of significance in Table XI.

TABLE XI. TEST SESSIONS IN RANK ORDER OF SIGNIFICANCE

Session	N	X^2
3	51	2.540
7	68	2.211
5	110	1.283
9	9	.857
8	12	.380
4	110	.350
1	111	.130
6	101	.078
10	6	.068
2	125	.004
Total	703	7.901

A X^2 of 7.901 has a probability of between .50 and .70 for 9 df.

Expected and observed passes and failures are summarized by session in Table XII.

TABLE XII. EXPECTED AND OBSERVED PASSES AND FAILURES BY TEST SESSION

		Session number									
		1	2	3	4	5	6	7	8	9	10
Pass	Observed frequency	13	10	2	16	12	16	11	1	2	2
	Expected frequency	13.7	10.1	3.6	17.3	10.1	16.6	8.7	1.4	1.4	2.2
Fail	Observed frequency	6	4	3	8	2	7	1	1	0	1
	Expected frequency	5.3	3.9	1.4	6.7	3.9	6.4	3.3	.6	.6	.8

Two sessions differed most significantly from what would be expected by chance. X^2 for these two sessions, Sessions 3 and 7, was 4.751 which has a probability between .02 and .05 with 1 df.

Large sessions were closest to expectation. X^2 for the five large sessions was 1.845 with a probability of between .70 and .80 with 4 df. The three small sessions had a X^2 of 1.305 for a probability of .50 with 2 df.

As the test was being given, notes were kept of unusual noises or occurrences. Two notes were taken for Session 3, the session which differed most from the expected. The first note says "best calibration in session 3." The second says "motor running in next room"--the ventilation blower room off the left side of the test room. More subjects than expected failed in Session 3. The notes may explain this difference.

There were also unusual occurrences in Session 7, the session that differed second most significantly from chance. Voltmeter readings were taken of signal levels at the speaker input for each session. This reading was constant for Sessions 1-6 and it was decided, starting with Session 7, not to recalibrate for subsequent sessions. For Session 8, the calibration was disturbed and in trying to reset the level by meter, it was found that meter readings at the speaker did not change appreciably for rather wide variations of calibration. Meter readings told nothing about the level of the tone. It is possible that Session 7 differs from other sessions because the test administered to Session 7 was calibrated on Session 6, a session with 101 subjects. Session 7, however, included only 68 subjects. Sound absorbtion differences may account for Session 7's significance. If this inference is valid, more subjects than expected would pass in Session 7, i.e., the level would have been set high. More subjects than expected did pass in Session 7. The expected frequency of passes was 8.7, the observed number was 11, 2.3 subjects above expectation.

X^2 for all sessions except 3 and 7 is 3.120 with a probability of between .80 and .90 with 7 df.

There is indication that brief noises do not significantly affect results, though continuous noises do. The continuous motor running may have affected the results in Session 3. Notes indicate that noises at the test room door were a problem the second day of the test, Sessions 4-10. Notes for the second day read: "Session 4: noise outside," and "Noise outside in Thursday sessions. No motor." A note for Session 8 says "Calibration off--low--squeaking noises coming from somewhere."

From these data, it appears probable that session size does not make a highly significant difference in test results. Large sessions appear to be most consistent, but small sessions do not differ significantly from expectation. It appears that the test must be recalibrated for each test session, at least where the number of subjects differs widely. Brief noises do not seem to cause major problems, though continuous noises do.

Failures by Frequency

Test results, as would be inferred from a report by Glorig[23] and subsequent experimentation by Ventry and Newby,[24] indicate that the 4000

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[23] Newby, op. cit., p. 209.

[24] Ira M. Ventry and Hayes A. Newby, "Validity of the One-Frequency Screening Principle for Public School Children," Journal of Speech and Hearing Research, II (June, 1959), 147-151.

cycle frequency, of the four test frequencies, correlated most highly with overall failures. Twenty-eight out of 37 subjects who failed the individual test also failed the group test at 4000 cycles.

Two subjects failed both tests at 500 cycles. Of these two, one also failed at 4000 cycles. Two subjects failed at 1000 cycles and both of these subjects also failed at 4000 cycles. Two subjects failed both tests at 2000 cycles. Of these, one passed and one failed at 4000 cycles. Of six failures at other than 4000 cycles, four also failed at 4000 cycles.

Test failures by frequency are summarized in Table XIII.

TABLE XIII. INDIVIDUAL AND GROUP TEST FAILURES BY FREQUENCY

		Group test							
		500		1000		2000		4000	
		Fail	Pass	Fail	Pass	Fail	Pass	Fail	Pass
IT	Pass	1	33	1	25	2	33	0	6
	Fail	2	1	2	0	2	0	28	3

From these data it appears that (1) 4000 cycles is the most significant test frequency, but (2) if only 4000 cycles were used in the test, subjects with significant losses would be missed.

Siegenthaler and Sommers[25] and Stevens and Davidson[26] indicate

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[25]Bruce M. Siegenthaler and Ronald E. Sommers, "Abbreviated Sweep-Check Procedures for School Hearing Testing," Journal of Speech and Hearing Disorders, XXIV (August, 1959), 249-257.

[26]Douglas Ann Stevens and G. Don Davidson, "Screening Tests of Hearing," Journal of Speech and Hearing Disorders, XXIV (August, 1959), 258-261.

that a satisfactory test should include at least 500 and 4000 cycles, preferably with 1000 cycles added. Too, it seems that it might be useful to add 6000 cycles to the test to differentiate between "traumatic" losses and more broad high-frequency losses. Since 500 cycles is easily masked by noise, it is not an entirely satisfactory tone for this type of test.

Summary of Test Items and Tones Missed

Group test items missed are summarized in Table XIV.

TABLE XIV. SUMMARY OF TEST ITEMS MISSED

Tone	Item number	Heard fewer tones than played	Heard more tones than played	Total
None	11	0	3	3
500	4	1	12	13
	8	3	0	3
	12	2	2	4
	Sub total	6	14	20
1000	1	4	0	4
	5	5	4	9
	9	2	3	5
	Sub total	11	7	18
2000	2	5	7	12
	6	4	6	10
	10	2	0	2
	Sub total	11	13	24
4000	3	37	0	37
	7	29	0	29
	Sub total	66	0	66
	Total	94 (72%)	37 (28%)	131

Table XIV may indicate two things. (1) Noise interfered with some test items, and (2) guessing was more of a problem than would be expected. Listening to the recording indicates another possible cause for the high percentage of tones heard when none were played. Though the tone portion of every item is relatively "clean," the narration contains an obvious hum. Subjects may have mistaken this hum for a test stimulus.

The results of Item 4 may indicate that 500 cycles is not a good frequency for a free-field test. The maximum number of stimuli were presented in Item 8; therefore, subjects could not mark that they heard more stimuli than were actually presented. Notes indicate that an unexpectedly large number of subjects missed Item 4 in Session 6. Eight of the 13 subjects who missed Item 4 were in Session 6.

Too, many more subjects than would be expected missed Item 3 in Session 5. Thirty-three out of 110 subjects missed the item. Six of the 37 subjects who missed Item 3 were in Session 5. Five out of these six did not have a 4000 cycle loss. Deducting these five subjects from those who missed Item 3 increases the apparent reliability of the 4000 cycle test frequency.

Interestingly, subjects with the most acute hearing seemed to miss the 2000 cycle items. Thirteen of the 24 subjects who mismarked these items had thresholds of -5 or -10, 5 or 10 db better than normal threshold. Perhaps there was a low level 2000 cycle noise in the test environment.

Unfortunately, subjects had no opportunity to hear more 4000 cycle stimuli than were played. Both items contained the maximum number of stimuli. Experience with audiometer tests indicates that subjects with 4000 cycle losses have a pronounced tendency to hear more stimuli than are actually presented. A revised test should probably contain items where subjects can record more 4000 cycle stimuli than were actually presented.

Twenty-eight per cent of the mismarked items indicated more stimuli were heard than were played. This probably accounts in large part for the negative correlation when using a single item missed as the criterion for failing the group test. This problem might be lessened (1) by trying to eliminate all extraneous noises from the test environment, particularly by choosing rooms that are not near distracting noises and by using test equipment that is in smooth running order, (2) by encouraging a positive attitude toward the test to reduce guessing, and (3) by retaping narration to eliminate hum.

Diminishing Tone Levels

The diminishing tone levels which were recorded into the test did not seem to provide any reliable indication of degree of hearing loss. Subjects with 25 db losses at 4000 cycles might indicate that they heard no tones or one or two tones when three stimuli had been presented. A subject sitting in the front of the room had a 20 db loss and heard no tones, but a subject sitting at the back of the room with a 40 db loss heard one tone in each of the 4000 cycle items.

Electrical Output of the Test Tape

Electrical output of the test tape was measured on two different tape recorders and on two different dates. A special tape was made for metering. Tones and levels for the metering tape were recorded at the same time the actual test stimuli were taped, but metering tones are played continuously for 15 seconds to allow the meter movement to settle. The first set of measurements was made at the monitor jack of the Magnecorder on which the test was recorded and played. The second measurements were made at the speaker input of a different tape recorder. The recorder's tone control, for the first set of measurements, was in the maximum treble position. The second sets of measurements were made with the tone control at both maximum treble and at maximum base. Results are summarized in Table IV.

TABLE XV. TONE INTENSITY DURING PLAYBACK

		First measurement				Second measurement			
		Max. treble				Max. treble		Max. bass	
Freq.	Theo. level	Level rel to 0 db	D[a]	Variation Av.	Variation Max.	Level rel to 0 db	D[a]	Level rel to 0 db	D[a]
1000[b]	0	0	0	1/4	1/3	0	0	0	0
500[c]	10	17	+2.0	1/5	2/3	15	0	16.5	+1.5
	15	22	+2.0	1/2	2/3	20	0	21.5	+1.5
	20	21.5	-4.5	1/4	1/3	18.5	-6.5	20.2	-4.8
1000	10	11	+1.0	1/4	1.5	11	+1.0	7.5	-2.5
	15	16	+1.0	1/2	1.5	16	+1.0	12.5	-2.5
	20	16.5	-3.5	1/4	1/4	14.5	-5.5	11.0	-9.0
2000	10	5.5	-4.5	1/3	1.0	8.5	-1.5	1.0	-9.0
	15	10.5	-4.5	1/3	1/3	13.5	-1.5	5.0	-10.0
	20	15.5	-4.5	1/4	1/2	18.5	-1.5	9.5	-10.5
4000	10	4.5	-5.5	1/4	1/2	12.5	+2.5	0.5	-9.5
	15	10.0	-5.0	1/4	1/3	17.5	+2.5	3.5	-11.5
	20	15.0	-5.0	1/4	1/3	22.5	+2.5	8.0	-12.0

[a] Difference from theoretical level.
[b] Reference level. All other levels are measured in relation to this level.
[c] This level was recorded 5 db high to compensate for normally lower acuity at this frequency.

Table XV indicates actual pressure levels were different from theoretical levels. The 20 db 500 and 1000 cycle tones differed significantly from the theoretical level in both sets of measurements. In the second set of measurements, all other tones were within from +2.5 to -1.5 db of theoretical levels. American Medical Association specifications allow a 4 db difference.[27] In the first set of measurements, however, the actual

[27] Hirsh, *op. cit.*, p. 306.

and theoretical levels differ by from +2 to -5.5 db. The large differences are at the two higher frequencies, 2000 and 4000 cycles. These frequencies are not within the 4 db allowed by specifications. The difference between the two sets of measurements is probably due to amplifier characteristics in the different recorders. The problem with the 20 db 500 and 1000 cycle tones was evident when the tape was being recorded and an unsuccessful attempt was made to bring these tones closer to theoretical level. The amplifier appears to be overdriven at these two levels.

Level differences between tones were excellent, again with the exception of the 20 db 500 and 1000 cycle tones. The greatest difference was between the 10 and 15 db 4000 cycle tones in the first set of measurements. This 1.5 db difference is the limit allowed by American Medical Association specifications.[28] The actual difference between most tones was "exactly" the theoretical difference.

The tone control setting does significantly affect signal levels. The difference between the "maximum treble" and "maximum bass" measurements would not necessarily apply to recorders other than the one on which measurements were made.

The average variation of a level, as measured with a voltmeter, was not great. Maximum variations occurred in no special pattern and did not always occur at the same spot as the tape was played back. Larger variations seemed to be caused by irregular operation of the tape transport mechanism.

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[28] Hirsh, op. cit., p. 305.

Actual sound pressure levels cannot be accurately inferred from these electrical pressure measurements. Loudspeaker characteristics might have great affect on actual sound pressure levels. It is obvious from test results that actual sound pressure levels were 10 to 15 db higher then either theoretical levels or actual electrical pressure levels. More careful calibration might make actual sound pressure levels closer to electrical and theoretical pressure levels.

Hearing Losses Discovered and Missed

Of the 33 subjects who failed the group test and took an individual test, 29 had a medically significant loss. Of the 29 with a significant loss, nine had a significant loss in just the worse ear. The group test, therefore, discovered nine subjects with medically significant monaural losses.

Thirteen subjects who passed the group test did, however, have a medically significant loss. Three subjects had a binaural loss that should have been discovered by the group test, even though the losses were not highly significant. These three subjects are discussed on pp. 19-21. Of the 125 subjects given audiometer tests, 10 had monaural losses which the group test would not be expected to discover.

It was hoped that the history subjects were to report on the answer sheet would help find monaural losses. Three of the 10 subjects with a monaural loss did report a history of hearing problems. Two of the 10 did not report a history on the test blank, but did report a history of ear infections at the time they were given the audiometer test. This may indicate both a tendency not to report history and that the answer sheet's request for history should be worded more exactly.

It appears that the test was satisfactory as a binaural test, discovering all subjects who would be at a real disadvantage in college because of their hearing. The test did serve its immediate purpose, but as a monaural test, it would serve an even more worthwhile purpose. The test could probably be adapted to a monaural test.

Time Required to Administer the Test

Time needed to play the total test tape is about eight minutes. Instructions for calibration take 50 seconds. The calibration tone is recorded for two minutes, but the test was always calibrated in less time. Instructions for the test proper take 2 minutes, 13 seconds. The test items run 2 minutes, 46 seconds.

Actual time consumed in administering the test was kept for sessions 4-7. Three monitors assisted with the test, passing out answer sheets, seeing that all seats were filled, and operating the test apparatus. Time was recorded for only some of the second day's sessions. The test was not administered as efficiently the first day as it was the second. Time consumed by the four test sessions is summarized in Table XVI.

TABLE XVI. TIME REQUIRED TO ADMINISTER THE TEST

Session	N	Time to fill room	Time to administer	Time to clear room	Total
4	110	---	15 min	2 min	--
5	110	2 min	12	2	16 min
6	101	2	15	2	19
7	68	4*	14	3	21

*Waited for subjects to arrive.

Table XVI indicates that, in general, it took longer to administer the test than it should. It does not seem unreasonable to assume that, as the test was given at South Dakota State College, experienced operators could complete a test session in 15 minutes, including the time needed to fill and to clear the room. At the rate the test was actually given, about 333 subjects an hour could be screened in the test room used. It seems reasonable that 444 subjects an hour could be screened by more efficient test operation. Larger rooms would allow even faster screening, though they might raise other problems. Quiet, wide auditoriums would be more ideal than the test room used in this experiment. Depending on facilities, the test might screen 1,000 or more subjects an hour. Even 333 subjects an hour is considerably faster than the 80-100 an hour that are screened by standard group tests.[29] Speed of administration is, of course, far from the most important consideration.

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[29]Newby, op. cit., p. 203.

Calibration

Calibration was the test's major weakness. First, it appears that the test was calibrated 10 to 15 db high. This difference may be, in part, due to different threshold levels for monaural and binaural hearing.[30] Too, the difference may be due to subjects lowering their hands too quickly as the calibration tone became difficult to hear. In large sessions, all subjects' hands tended to go down at the same time. Subjects seemed to fear being the only one in the room with their hand still up. Noise gave away the fact that others were lowering their hands.

Calibration might be improved in four ways: (1) have subjects indicate threshold several times, encouraging them to listen very carefully as threshold is crossed three or more times; (2) arbitrarily reduce threshold 10 to 15 db by using a db meter; (3) explain the purpose of calibration more carefully; (4) reassure subjects that it is all right to be the only one in the auditorium with his hand still up.

Comparing Answers

There was indication that subjects compared answer sheets, especially during the break between the sixth and seventh items. Perhaps this pause is unnecessary and should be eliminated. Some test blanks indicate subjects did change answers from wrong to correct responses. Subject 616, for instance, marked Items 3 and 7 zero, but had changed Item 3 to the correct answer. Both of these items were 4000 cycle items, and this sub-

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[30] Hirsh, op. cit., pp. 234-235.

ject had a 35 db loss at this frequency in both ears. Subject 642 did the same thing, but erased his correct answer. Subject 660 missed Item 7 and had changed Item 3 from zero to the correct answer. An observer reports that subjects compared answers in Sessions 5 and 6.

Comparisons might be reduced by allowing as little time as possible for them and by assuring subjects that test results would not affect their college entrance.

SUMMARY

Procedure

The four frequencies most important to speech were recorded at three different levels on a tape recorder and played back to test subjects over a single loudspeaker. For calibration, a reference level tone was recorded at 1000 cycles per second. The test was calibrated on this tone by having subjects lower their hands when they could no longer hear the calibration tone, i.e., when the tone was at zero sensation level.

The test is a pulse-tone test, subjects indicating on an answer sheet the number of stimuli they hear in each of 12 test items. From 0 to 3 stimuli were presented in each item. Each stimulus was presented twice at each level, the time difference between like tones being long enough that intermittent noises were unlikely to mask the same tone twice.

The test was given to 703 entering freshmen at South Dakota State College in 10 different sessions. There were from 6 to 125 subjects in each session. One-hundred twenty-five of these 703 subjects were also given individual pure tone audiometer tests. Fifty of these 125 either missed items on the group test or indicated a history of hearing or ear trouble. The other 75 were chosen at "random."

Results

The best fail criterion for the group test was found to be two items missed at the same frequency.

The phi coefficient correlation between the group test and the individual audiometer test was .62 for a random sample of 75 subjects. Three subjects out of the 75 had losses that should have been discovered by the group test. Binaural loss for these three subjects was 2.2, 2.2, and 1.8 per cent.

Phi coefficient correlations for those who missed items on the group test or indicated a history of loss was .78. Neglecting those who failed the group test and passed the individual test, i.e., those who were unnecessarily given the audiometer test, the correlation for the error and history sample was 1.00.

Correlation for the entire sample was .84. Correlation for the entire sample, neglecting those who were given the audiometer test unnecessarily, was .93.

The group test was failed by 6.1 per cent of the population. An estimated 5.4 per cent of the test population had a medically significant loss that was discovered by the group test.

Seating position did make a significant difference. Seating by sides or center of the room did not make a significant difference, though it did not make a highly insignificant difference. Probability was between .50 and .70 for differences by room side.

Seating position from front to back of the room made the most significant difference. Probability that the distance from the speaker did not make a significant difference was between .05 and .10. More failures than would be expected occurred in the back rows, fewer in the front. There is some indication that diminishing sound pressure may not be the only cause of this difference.

The test was given 10 times. There was no significant difference from test session to test session. Sessions contained from 6 to 125 subjects. Probability for the eight least significant sessions was between .80 and .90. Noise and calibration problems caused difficulties in the other two sessions. The test should be recalibrated for each test session, at least where the number of subjects varies appreciably.

Most group test failures were at 4000 cycles.

An analysis of test items and tones missed indicates that noise masked some tones. Too, there is indication that guessing may have been a problem. Twenty-eight per cent of the mismarked items indicated subjects heard more stimuli than were actually presented.

Diminishing tone levels that are recorded into the test tape appear to give no reliable indication of degree of loss.

Electrical measurements indicate that actual tone levels differ from theoretical levels, but this difference, with the exception of the 20 db 500 and 1000 tones, is not a serious problem. The difference between levels within a test item was generally excellent. The setting of the playback equipment's tone control significantly affects output levels. Variation of levels as the tape is played were not excessive.

Ten subjects, of the 75 in the random sample, were found to have a medically significant monaural loss which this binaural test would not be expected to discover. Three of these ten subjects indicated a history of hearing problems on their answer sheets. Two other subjects reported a history when given the audiometer test, but had not indicated history on the group-test answer sheet.

It took about 20 minutes to administer the test, including time for filling and clearing the test room. Time can probably be reduced.

The method used for calibrating the test was not satisfactory. The test was calibrated 10 to 15 db high.

Subjects tended to compare answers, especially during the break between the sixth and seventh test items.

Suggested Improvements

The major weakness of the test was calibration. Calibration might be improved by crossing subjects' thresholds several times. This would accustom them to listening intently and could eliminate embarrassment in present calibration procedures.

The second most important weakness is the difference in results obtained for the front and back of the room. This weakness could be reduced, where possible, by choosing wide rooms and seating subjects toward the back of the room. "Causes" for this difference should be investigated further by seating subjects in random order.

A third improvement that should be made is to encourage a positive attitude toward the test to reduce fear, guessing, and copying from others. Eliminating the pause between Items 6 and 7 would eliminate time for comparing answers.

More emphasis should be placed on the 4000 cycle frequency. Some 4000 cycle items should contain fewer than three stimuli.

The answer sheet's request for history should be more specific.

The test would be more valuable if it were adapted to a monaural test.

Conclusion

The test satisfactorily performed its intended function.

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APPENDIX

APPENDIX A

TAPING PLAN

Calibration

0:00 NARRATOR: A tone that sounds like this . . .

TONE: 1000 cycles at 35 db. 2 seconds.

NARRATOR: . . . will follow this explanation. At the end of the explanation, you'll be asked to close your eyes and to raise your hands. This tone will be played loudly enough to be heard by nearly all of you; then the volume will be reduced until you can no longer hear it. When you can no longer hear the tone, quietly lower your hand.

Be as quiet as possible. Such things as shuffling feet, shifting posture, clearing throats, and releasing air from the lungs may tend to hide the tones.

Close your eyes and raise your hands now. Quietly lower your hand when you can no longer hear the tone. Open

0:50 your eyes after you've lowered your hand.

TONE: 1000 cycles at 0 db. 2 minutes.

2:52 NARRATOR: End of calibration tone.

The Test

0:00 NARRATOR: This is a hearing survey. Its purpose is to locate and help students who might be at a disadvantage because of their hearing.

Twelve sets of tones will follow. For each set, mark whether you hear zero, one, two, or three tones. There'll be no more than three tones in each set.

Be as quiet as possible while the tones are being played. Noises that might hide the tones, for you or for others, include sighing, shifting posture, shuffling feet, and so forth.

As you listen, face front.

The first set of tones you hear will be a sample set, played so you can hear how the tones will sound and practice using the answer sheet. There'll be a question period at the end of the sample tones.

After the question period, the first six sets of tones will be played. At the end of the first six sets, there will be a 20 second pause for you to change posture, take a deep breath, or just briefly relax.

After the pause, the last six sets of tones will be played.

The number of the item signals that the tones will follow shortly. These numbers are spoken rather softly, so listen for them carefully.

After a set of tones has been played, you'll hear the word "mark," meaning to mark your answer sheet by putting an X in the square under the number of tones you heard--zero, one, two, or three. If you count the tones on the answer sheet as you hear them played, remember to start counting on the answer sheet with the number one, not with the zero.

The sample set of tones will now follow. Remember to be as quiet as possible and to face front.

Sample.

TONE: 1000 cycles at 35 db. Three one-second tones, with one second of silence between tones.

NARRATOR: Mark. Most of you should have put an X in square under the three.

2:13 Are there any questions? (Shut off tape transport.)

Tone Schedule

(The tone schedule follows. Each item number is announced by the narrator. There is a slight pause; then the first tone is presented. Tones are one second in duration with a second of silence between tones. Where fewer than three stimuli are presented, tones follow the announcement of the item number and after the stimuli have been presented, silence fills the time of missing stimuli.)

0:00 NARRATOR: Number one.

TONES: 1000 cycles at 20, 15 and 10 db.

NARRATOR: Mark.

(And so forth for each item.)

Item number	Frequency	Levels
1	1000	20, 15, 10 db.
2	2000	15, 10.
3	4000	20, 15, 10.
4	500	15.
5	1000	20.
6	2000	20.

1:11 NARRATOR: There will now be a short pause.

PAUSE: 25 seconds.

1:36 NARRATOR: The last six sets of tones follow.

Item number	Frequency	Levels
7	4000	20, 15, 10 db.
8	500	20, 15, 10.
9	1000	15, 10.
10	2000	20, 15, 10.
11	None	None
12	500	20, 10.

2:51 NARRATOR: This completes the hearing survey.

TIMING

Instruction for calibration.	:50	
Calibration tone.	2:00	
End of calibration narration.	:02	
Sub total		2:52
Instructions for test.	2:13	
Test	2:51	
Sub total		5:04
Total		7:56

APPENDIX B

INSTRUCTIONS FOR ADMINISTERING AND SCORING THE TEST

I. Before subjects arrive.
   A. Set up the test apparatus. Warm up the recorder.
   B. Set the tone control at full treble.
   C. Set the recorder's volume control at a comfortable level with the attenuator switch in the "Narration" position.
   D. Set attenuator at minimum attenuation.
   E. Cue the test tape at the beginning of calibration instructions.

II. When subjects arrive.
   A. Hand out answer sheets.
   B. Have subjects fill in the top and bottom of the answer sheet.
      1. Tell them the session number.
      2. Tell them where to find their seat number.
      3. Ask them to fill in the bottom of the form.
   C. Explain the test.
      1. It is in two parts.
         a. Calibration.
         b. Test proper.
      2. Instructions are recorded on the test tape.

III. Announce, then begin calibration.
   A. Play instructions with attentuator switch in the "Narration" position.
   B. At end of instructions, put attenuator switch in "Test" position.
   C. Slowly fade the attenuator until an estimated 50 per cent of the subjects have lowered their hands.
   D. Tell those with their hands still up that they may lower them.
   E. Run the tape to the beginning of the test instructions. Do not move either of the volume controls.
   F. Set attenuator switch in "Narration" position.

IV. Announce instructions for the test proper will follow.
   A. Play test instructions.
   B. (<u>QUICK</u> <u>CUE</u>) At the end of the following, put the attenuator switch in the "Test" position. <u>"The</u> <u>sample</u> <u>set</u> <u>of</u> <u>tones</u> <u>will</u> <u>now</u> <u>follow</u>. <u>Remember</u> <u>to</u> <u>be</u> <u>as</u> <u>quiet</u> <u>as</u> <u>possible</u> <u>and</u> <u>to</u> <u>face</u> <u>front</u>." Throw switch to "<u>TEST</u>" position.
   C. (<u>QUICK</u> <u>CUE</u>) After the word "<u>MARK</u>", throw the switch to "<u>NARRATION</u>."
   D. (<u>QUICK</u> <u>CUE</u>) After "<u>Are</u> <u>there</u> <u>any</u> <u>questions?</u>" <u>STOP</u> the transport mechanism.
   E. Put the attenuator switch in the "<u>TEST</u>" position.
   F. Answer questions.

V. Announce the beginning of the test items.
   A. Start the transport mechanism.
   B. (QUICK CUE) After the word "Mark" at the end of Item 6, set the attenuator switch in the "NARRATION" position. The rest break is timed on the tape.
   C. (QUICK CUE) After "The last six sets of tones follow," set attenuator switch in "TEST" position.
   D. (QUICK CUE) After the word "Mark" following Item 12, set the switch in the "NARRATION" position.
   E. After "This completes the hearing survey," shut off the tape transport mechanism.
   F. Rewind the tape for the next session. Leave attenuator switch in "NARRATION" position.
   G. Set attenuator at minimum attenuation.
   H. Repeat steps II through V.

VI. Score answer sheets by items marked incorrectly. Fail those who marked two or more items incorrectly at the same frequency.

Frequency	Item numbers
1000	1, 5, 9
2000	2, 6, 10
4000	3, 7
500	4, 8, 12

APPENDIX C

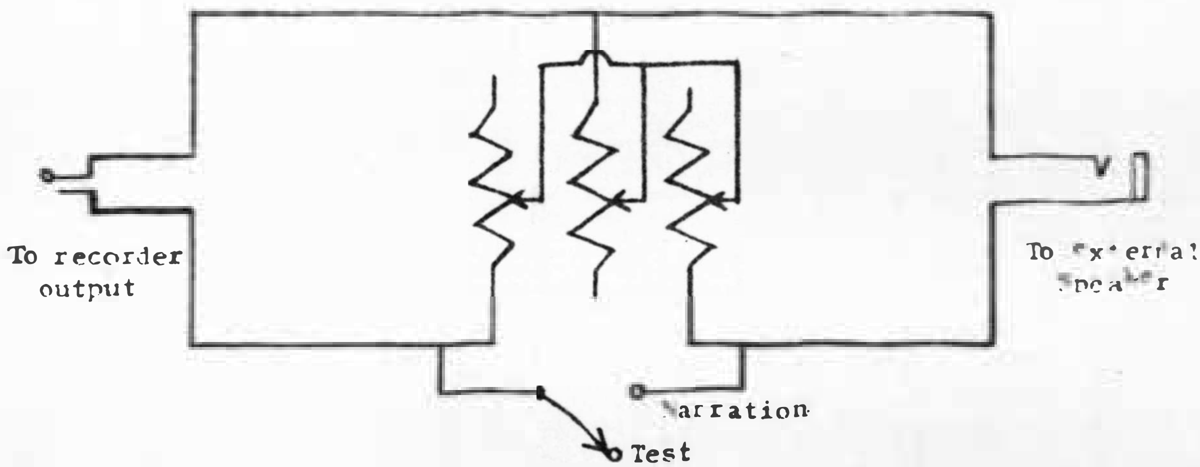
AUDIOMETER CALIBRATION CHECK

Subject	500	1000	2000	4000
317	5	0	-10	-5
321	15	10	5	0
557	10	5	0	5
135	5	0	-5	-5
315	0	-5	-5	-10
182	-5	-10	-10	-5
273	5	5	-5	5
603	5	-5	0	-10
512	0	-10	-10	-5
408	5	0	-5	-10
61	5	5	0	-5
462	-5	-5	-10	-10
338	0	-5	-10	5
555	5	5	-5	-10
421	0	0	-10	-10
468	0	0	5	-10
523	0	0	5	15
599	5	5	15	10
470	-5	0	-10	-10
489	5	0	0	0
403	0	0	-5	-5
264	10	0	-10	-10
528	10	5	-5	-5
70	0	0	-5	-5
350	5	5	-5	0
Total	80	5	-95	-90
Average	3.2	.2	-3.8	-3.6

APPENDIX D

CALIBRATION ATTENUATOR

Schematic Diagram



Materials and Approximate Prices

Quantity	Description	Net Price
1	4 ohm, Clarostat Series CIT T pad	$3.15
1	SPST switch	.66
1	Short frame phone jack	.24
1	Phone plug	.33
1	LV-3006-A Minibox	.82
	Total	$5.20

APPENDIX E

TABULATED RAW DATA

Frequency			500 IT					1000 IT					2000 IT					4000 IT				FAIL GT			
Item no.			4	8	12	R	L	1	5	9	R	L	2	6	10	R	L	3	7	R	L	1st			
Correct response			1	3	2			3	1	2			2	1	2			3	3						
Session	Seat no.	Subject	Error and history sample (N=50)																			2+	2+	1+	IT
1	-	611																1	0	15	50	F	F	F	
	-	189											1			-5	-5	0	0	45	40	F	F	F	F
	60	616				15	20											0	0	35	35	F	F	F	F
	136	618				15	10											1	1	40	40	F	F	F	F
	143	185																0	0	25	35	F	F	F	F
	144	630				15	5				20	0						0	0	65	30	F	F	F	F
2	-	646																0	2	40	25	F	F	F	F
	-	635	1		1	35	25	2	0	0	55	45	1	0	0	55	45	0	2	40	30	F	F	F	F
	-	190											1			-10	-5	2		-5	-5		F	F	
	-	198																0	0	50	55	F	F	F	F
	-	639	1			5	5																	F	
	44	193				15	0				20	0													
	49	637																							
	92	619						0	0	0	30	35	1		1	40	40			25	35	F	F	F	F
3	97	636														30	-5	0	0	65	55	F	F	F	F
	124	620																0	0	55	50	F	F	F	F

4	54	625	2		0	5					3		-10	-5						F	F	
	66	643													0	0	50	50	F	F	F	F
	67	614													0	0	30	45	F	F	F	F
	69	187													2	1	35	45	F	F	F	F
	101	638													0	2	55	25	F	F	F	F
	106	640		3	-5	0	2	3	-10	0	3		-10	-5	2		15	-5	F	F	F	
	115	200									3	2	-10	-10	1	0	30	45	F	F	F	F
	125	613											15	15	0	0	40	45	F	F	F	F
	146	621	3		-5	0	2		0	0	3	2	-5	0					F	F	F	
5	54	612																				
	85	195															10	20				
	97	631	2		0	0	0		5	5		0	-5	0						F	F	
	124	191														0	-5	10			F	
	121	634			25	5			20	0			20	5	1	1	25	15	F	F	F	
6	39	70																				
	41	629						3	-5	-5					0	0	20	35	F	F	F	F
	81	626													1	2	25	45	F	F	F	F
	89	147	2	3	15	10						2	-5	5					F	F	F	
	99	645	0		10	15	0		5	10										F	F	
	100	642											20	0	0	0	40	35	F	F	F	F
	101	624	3		-5	5									0		0	0		F	F	
	120	184													0	0	45	35	F	F	F	F
	122	647			15	5			15	-5			35	-5			30	-10				
	137	633													0	0	25	25	F	F	F	F
	138	196			25	5									0	0	45	45	F	F	F	F
	140	628	2		0	5	2		0	-5							10	35		F	F	
	144	641	2		5	15					3		0	5						F	F	
	146	192	3		0	-5					3		-10	-10						F	F	
7	61	622																				
	140	188	3		10	10	2		15	5		2	5	15	2	2	25	25	F	F	F	F

8	92	623															45	10				
	130	632	2	1	25	20			20	15	3		35	0			35	5	F	F	F	F
9	80	644	2		10	10		3	5	0										F	F	
10	132	615													0	0	25	40	F	F	F	F

Random numbers sample (N=28)

1	-	112																				
	-	157																				
	-	102																				
	-	174																				
	38	108																				
	64	135																				
	111	132																				
2	67	443			20	20																F
	76	442																				
3	88	380																				
4	60	676									2		0	15			20	35			F	F
	87	693									2		-10	-5							F	
	103	596																				
	105	603																				
	110	548																				
5	55	204													2		-5	0			F	
	96	224													1		30	20			F	F
	111	627					2		-10	-5	1		-10	-10	2		0	-5		F	F	
	125	194													0	0	60	50	F	F	F	F

6	55	3	2	5	5								F
	62	43											
	64	6	2	-5	0								F
	83	62									10	30	
	123	63											
7	79	310											
	95	315											
	101	350											
	141	317											

Speech and English class sample (N=47)

-	-	469											
-	-	468											
-	60	462											
	92	470											
	94	512											
	103	519											
	105	521											
1	-	144											
	-	186											
	-	656								1	15	35	F
		101		20	15	15	0	25	-5		40	15	
	67	142											
	92	130											
2	-	421											
	-	523											
	72	408											
	79	653											

3	90	648								0	0	70	70	F	F	F	F
	105	403															
4	41	599															
	42	557															
	63	551										5	25				
	71	597															
	78	528															
	85	589															
	102	675		2	0	-5	0	-10	-10						F	F	
	111	550															
	127	555															
	131	585															
5	57	264															
	62	280															
	67	273															
	79	223								2		0	0			F	
	134	271															
6	51	617								2		15	40		F	F	
	54	685		0	-5	-5	0	-10	-10						F	F	
	107	53															
	124	61															
7	54	199															
	58	351															
	94	313															
	120	338															
	142	319										5	40				
	145	221															

9	164	297				
10	30 144	183 182		15	15	